MAR 6 '86

431-L-12 EPA 89/2: 600/S2-85/117

United States
Environmental Protection
Agency

Hazardous Waste Engineering
Research Laboratory
Cincinnati OH 45268

Research and Development

EPA/600/S2-85/117 Dec 1985

EPA

Project Summary

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Emission Assessment of Refuse-Derived Fuel Combustion: Suspension Firing

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ORIGINAL

Increased interest in developing acceptable methods for recovering usable energy from municipal waste has brought about the need to investigate potential emissions from three combustion modes which could be used in burning refuse-derived fuels (RDF). Laboratory-scale experimental studies were carried out to evaluate fuel/combustion characteristics and emissions during co-firing of coal and RDF fuels using:

- grate (or bed) burning
- suspension burning
- fluidized bed burning

The full report presents the results for suspension firing.

The suspension burning investigation was conducted in a horizontal laboratory boiler firing at a nominal heat input of 440 kW. The boiler had been modified to simulate large utility boilers as well as to permit co-firing and tri-firing of coal, RDF, and hazardous liquids. During the study, the following conditions were investigated:

- RDF type
- RDF/coal ratio
- RDF/coal/hazardous waste ratio
- excess air
- staged combustion
- hazardous waste type

A powder type RDF was co-fired with coal at ratios up to 50 percent (heat input basis) and tri-fired with pulverized coal and hazardous liquid waste (40 percent/40 percent/20 percent, respectively on a heat input basis). A fluff type RDF was also co-fired with coal.

Emission measurements were obtained for a large number of co-fired conditions; many showed reduced nitric oxide emissions with co-firing relative to coal-only combustion. Organic and inorganic samples showed only two combustion conditions where polynuclear aromatic hydrocarbons (PAHs) were present. Both of these occurred during tests with tri-fired powder RDF, coal, and waste oil. Screening tests showed levels of dioxins and polychlorinated biphenyls (PCBs) were below threshold values.

Suspension firing of the fluff type RDF was not satisfactory above 10 percent Btu basis due to incomplete combustion of the larger particles in the primary burner.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background and Objectives

Most incinerators which burn municipal refuse do not produce steam and all the heat generated is lost. There have been some attempts to utilize this source of heat by adding steam or hot water generating equipment to municipal incinerators. Since most of these heat recovery effects involved add-on devices, they were usually of low thermal efficiency when compared to utility or industrial steam generation boilers.

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Since utility boilers have the potential for handling large amounts of municipal solid waste with efficient heat recovery, a number of feasibility studies on large utility boilers such as St. Louis/Union Electric were undertaken. Unfortunately, large commercial utilities have little economic incentive to pursue the use of refuse-derived fuel (RDF) as a power plant supplemental fuel because they have favorable long-term fuel contracts plus fuel cost pass-through provisions.

On the other hand, smaller industrial boilers may be a more likely candidate for using municipal waste as a supplemental fuel source. Based on Federal Energy Administration estimates, over 15 percent of all the energy consumed in the United States is utilized by industrial boilers to generate process steam. The total annual energy consumption by these boilers is in excess of 9,300 trillion kJ's.

The range of equipment used to combust fuels in either industrial or utility boilers is wide and the types of fuels are varied. The focus in this research program was on coal firing using three current modes of combustion considered suitable for either sector. These modes are:

- Suspension Firing
- Overfired Stoker Combustion
- Fluidized Bed Combustion

The objective of the overall program was to obtain an emission assessment of these three modes of combustion when co-firing a base coal and refuse-derived fuels (RDF). The full report addresses the evaluation of suspension fired emissions of co-fired coal and two types of RDF. Due to the increased interest in hazardous waste disposal, an assessment of co-fired or tri-fired coal/RDF/hazardous waste was also included in the program.

Experimental Apparatus and Approach

The experiments were conducted in a multifuel combustion facility capable of solids fuel firing rates to 880 kW. All of the experiments in this study were conducted at 440 kW. The basis of the combustion facility was a 780 kW firetube boiler which had been extensively modified to simulate utility boiler conditions. This included an indirectly fired air preheater, a scaled-down utility boiler burner, radiation shields to increase the thermal environment in the combustion chamber, and capabilities to achieve staged combustion.

The system was set up to allow separate delivery of the pulverized coal, RDF, and hazardous liquid waste to the combustion chamber. The pulverized coal and the RDF were pneumatically conveyed to the burner using a portion of the combustion air. Exhaust ducts were sized to achieve isokinetic sampling of particulate emissions. A systematic set of experiments was conducted which investigated the following variables.

- RDF type
- RDF/coal ratio on a Btu basis
- RDF/coal/hazardous waste ratio
- Excess air
- Staged combustion
- Hazardous waste type

During the experiments the combustion products were monitored for O_2, CO_2, CO, NO, SO_2, SO_3, opacity, particulate loading, particulate size distribution, trace element, and halogen emissions.

Results

RDF Fuel Handling and Combustion Characteristics

Two different types of RDF were utilized in this program; one RDF can be referred to as a powder and the other a fluff.

The powder RDF was easily combusted when co-fired with coal in the suspension firing boiler to heat input fractions of 50 percent RDF. The maximum feed rates of powder RDF to the boiler were limited by the fuel supply systems available for the program rather than any combustion characteristics of the RDF fuel.

With the fluff RDF it was not possible to achieve complete combustion of the RDF in suspension firing above 10 percent RDF (on a heat input basis). At feed rates approaching 20 percent the RDF burned partly in suspension and partly on the floor of the combustion chamber. The fuel feed system for the fluff RDF was not capable of transporting the plastic materials contained in this type of RDF. Heavy duty plastic trash bag liners were particularly difficult to shred and thus caused numerous solids handling and transport problems.

Emission Characteristics

Base Coal

The base coal was fired at excess air levels between 20 percent and 70 percent for single-stage combustion and at a fixed excess air level of approximately 30 percent with staged combustion. Emission characteristics were determined for gaseous and solid components as a basis of comparison for the co-fired and tri-fired tests.

Co-Fired Fuels

Two different RDFs and two different hazardous waste liquids were co-fired with the base coal. The criteria emissions were measured for all test points. These co-fired tests showed nitric oxide emissions in all cases to be lower than for the base coal. Carbon monoxide emissions were unchanged and sulfur oxide emissions were lower as compared to the base coal.

Limited trace element measurements and halogen emission measurements were made. The majority of these measurements were made for various percentages of the two RDFs co-fired with coal. Chlorine was the major halogen emission and the concentration increased as the percentage of RDF fired was increased. Principal trace elements found in the flue gas were those present in the RDF and coal. Analyses for polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), and dioxins, showed concentrations were well below levels of concern for all conditions sampled.

Tri-Fired Fuels

Tri-firing was accomplished for each of the two hazardous waste liquids (benzene and waste lubricating oil) in combination with coal and the powder RDF.

The conclusions from the measurements made during these tri-fired experiments are the same as for the co-fired fuels.

Conclusions

The major conclusions that can be drawn from the results of the study include:

- The fluff type RDF did not exhibit acceptable combustion characteristics at RDF/coal ratios above 10 percent (on a heat input basis) with pulverized bituminous coal.
- The powder RDF exhibited suitable combustion characteristics when co-fired in suspension firing at ratios up to 50 percent (on a heat input basis) with pulverized bituminous coal.
- Staged combustion was effective in reducing nitric oxide emissions for both RDF/coal combinations. The particulate emissions increased with staged combustion.

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- The trends observed in NO_x emissions versus excess air were similar for coal only, co-fired, and tri-fired combustion. A slightly lower nitric oxide emission for multifuel combustion compared to coal-only combustion was observed.
- Changes in the trace element concentrations due to co-firing or tri-firing were detected. The increase in chlorine emissions were comparable to the increase in chlorine content of the RDF relative to the coal.
- For all conditions tested, concentrations of PCBs, PAHs, and dioxins were within acceptable limits.

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The complete report, entitled "Emission Assessment of Refuse-Derived Fuel Combustion: Suspension Firing," (Order No. PB 86-114 725/AS; Cost: $16.95, subject to change) will be available only from:
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